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Department of Education

COURSES OF STUDY

GRADE XIII

BIOLOGY

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BOTANY AND ZOOLOGY

This course in Botany and Zoology has been outlined in detail in order to give the teachers a definite guide as to what topics should be studied. The number of periods (each of approximately 40 minutes) given is merely a suggestion or guide as to the depth of treatment.

The sequence of topics as presented is suggested as a logical arrangement in order to take advantage of the specimens when available. Teachers, however, should feel free to teach the work in any order which they consider satisfactory. Some may wish to teach the frog, for instance, before the human physiology. In such cases, more time will be required for this topic and less time will be needed for human physiology. Needless repetition should be avoided. In many cases the names of the parts of a particular plant or animal are listed in order to set the limits for examination purposes but the listing of all these parts does not call for a detailed description. Actually many of them are not of sufficient importance to warrant intensive treatment. Observational drawings for both Botany and Zoology are essential.

BOTANY

Angiosperms
The Flower
(Twelve periods)

Review the essential and accessory parts of the flower with their functions; complete and incomplete, perfect and imperfect flowers; adhesions of flower parts, (hypogynous, epigynous, perigynous, epipetalous, inferior, superior).

Using a minimum of technical terms make a practical study of one representative of each of the following families as a basis of classification: Ranunculaceae, Cruciferae, Scrophulariaceae, Leguminosae, Compositae, Liliaceae, Aceraceae, and Rosaceae. It is preferable to teach some of these in the Spring term when the representative plants are available. The characteristics which distinguish one family from another, as listed in a botany key, should be studied. A detailed study of the flower should be made and only those features of the stem, roots, and leaves which are definite family characteristics should be stressed. Identification with the botany key, "Wild Plants of Canada", of at least one plant studied; **genus and species to be used only to indicate the principles of nomenclature.**

Pollination
(Three periods)

Microscopic study of pollen grains; cross- and self-pollination; agents of pollination; adaptations of flowers for wind and insect pollination; adaptations for cross-pollination—imperfect flowers, dichogamy, sterility of pollen, shape of flower; advantages and disadvantages of cross- and self-pollination; artificial pollination.

Fertilization
(Two periods)

Germination of pollen grain; ovule structure; fertilization (and double fertilization); and subsequent development in seed and fruit formation.

The Fruit
(Two periods)

Reference should be made only to those examples (achene, silique, legume, berry, capsule, pome, drupe, and samara) which occur among the representative families

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of Angiosperms studied. Distinguish types of fruits—simple, aggregate, or multiple; fleshy or dry (dehiscent and indehiscent).

The Seed (Four periods)

Practical study of corn and bean seeds—internal and external views. Parts and functions of the corn; seed coats (protection); endosperm (food for embryo); embryo-cotyledon (absorption and digestion of food), plumule (future shoot), hypocotyl (future lower part of stem or root) and radicle (future root system). Similar treatment of bean seed, stressing that it has two cotyledons in the embryo and lacks endosperm.

Experiment to demonstrate respiration in germinating seeds as shown by the liberation of carbon dioxide.

The Cell (Six periods)

Microscopic study of a normal plant cell—(Elodea or Spirogyra) including cell wall, protoplasm, nucleus, cytoplasm, cytoplasmic membrane, plastids, starch grains and vacuole.

Mitosis—diagrammatic representation of cell division, (phase names not required).

Entrance and exit of materials—Review diffusion (Grades XI and XII Chemistry); simple experiments to illustrate (a) osmosis and (b) plasmolysis of a cell. Reference to turgor and plant-wilting.

The Root (Seven periods)

Classification according to origin, form and duration. Study of root-tip as shown in rooted cuttings (geranium) or seedling (radish).

Experiment to show region of elongation in a root tip. Microscopic study of (a) longitudinal section of root tip, noting the function of each part; (b) cross-section of young dicotyledonous root in the root-hair zone indicating epidermis, cortex, endodermis, stele (pericycle, phloem, xylem, parenchyma). Give the function of each of the parts. Indicate differentiation of parenchyma cells into vascular tissue. Reference to the difference in the arrangement of vascular tissue in the monocotyledonous and dicotyledonous roots.

Root-hairs—origin, location, structure, duration, and function. Development of branch roots; secondary thickening.

Function of roots—(a) general (anchorage, absorption of water and mineral salts, and conduction); (b) special (storage, propagation, and parasitic habit).

The Stem (Nine periods)

Classification of stems as to form (excurrent and deliquescent). Examination of green and woody shoots to show growing points, arrangements of leaves, buds, branches, nodes, lenticels, leaf-scars, and bud-scale scars. Microscopic study of a cross-section of a herbaceous dicotyledonous stem showing epidermis, cortex, pericycle, vascular bundle (phloem—sieve tubes and companion cells; cambium and xylem—tracheal tubes), pith ray, and pith. Discuss differentiation of cells into vascular, mechanical, and storage tissue.

Cross-section of monocotyledonous stem (corn) as seen under the low-power microscope indicating epidermis, parenchyma, vascular bundles (phloem—sieve-tubes and companion cells; xylem—tracheal tubes; bundle sheaths).

Functions of stem—(a) general: support of leaves, flowers, fruits, and seeds; production of buds; conduction of water and food; (b) special: reproduction (cuttings and grafting); photosynthesis; storage (rhizome, tuber, corm, and bulb); climbing (twining stems); protection (thorn

Experiments to show responses to gravity and light.

Reference to other stimuli—touch, chemicals, and moisture. Experiment to show the region of elongation of an herbaceous dicotyledonous stem.

Comparison of roots and stems under the following headings: protection of growing points, tropisms, absorption organs, branching, and nodes.

The Leaf
(Thirteen periods)

External features—blade, petiole, stipules, compounding, and venation. Microscopic study of (a) a cross-section of a leaf indicating cuticle, epidermis, guard-cells, stomata, mesophyll (palisade and spongy tissues), airspaces and veins; (b) a leaf epidermis to show epidermal and guard-cells. Reference to the opening and closing of these stomata.

General functions—(a) **Photosynthesis**—chlorophyll, raw materials, energy source, and products. Experiments to show (1) starch is manufactured by green tissue during light exposure; (2) oxygen is released; (3) chlorophyll is necessary; (4) carbon dioxide is essential for photosynthesis.

(b) **Respiration**—Recall experiment on germinating seeds to show that carbon dioxide is produced. Discuss respiration in leaves. Contrast photosynthesis and respiration under the following headings: energy change, raw materials, times of occurrence, cells involved, and products.

(c) **Transpiration**—Experiment to demonstrate water loss. Conditions affecting transpiration rate: (1) leaf structure and habits (leaf thickness, leaf area, cuticle, stomata, leaf fall, and leaf curling); (2) light; (3) evaporating power of the air; (4) water content of the soil. Application of some of these factors in transplanting.

Fall of the leaf—abscission layer; deciduous or evergreen habit.

Special functions of the leaf—storage, propagation, protection, climbing, and capture of insects.

Thallophytes
(Thirteen periods)

Spirogyra: (a) Habitat, (b) Cell structure, (c) Reproduction: fragmentation and conjugation.

Mushroom: (a) Habitat, (b) Structure: sporophore—stalk, cap, ring, gills, hyphae, and mycelium. (c) Reproduction: spores, mushroom "spawn", fragmentation of mycelium.

Lichen: (a) Habitat, (b) Types: crustose, foliose, and fruticose; (c) Structure of a lichen noting the symbiotic relationship between an alga and a fungus and stressing the protective and nutritive roles of the fungus and alga, respectively; (d) Reproduction: soredia, ascospores, and fragmentation.

Bacteria: (a) Habitat, (b) Forms, (c) Reproduction, (d) Beneficial effects (soil fertility, decay, making of vinegar, sauerkraut, souring of milk, "ripening" of cheese, curing of tobacco, and ensilage); harmful effects (diseases and spoiling of food). Carbon and Nitrogen Cycles (Chemistry—a First Course, p. 222 for the latter).

Yeasts: (a) Habitat, (b) Cell structure, (c) Reproduction (budding and ascospores), (d) Economic importance (production of ethyl alcohol and making of bread); reference to anaerobic respiration and enzyme action.

Apple Scab: (or Black Knot)—host, appearances, life cycle (conidia, and ascospores), economic importance, and control.

Wheat Rust: (or Pine Rust)—hosts, appearances, life cycle (summer, winter, spring and cluster cup spores, reference to sex), economic importance and control.

Bryophytes (Two periods)

Moss: (a) Habitat, (b) Structure: (i) gametophyte—general features of the stem and leaves of the "moss plant", rhizoids, terminal archegonia and antheridia, motile sperms, and egg; (ii) sporophyte—foot, stalk, and capsule (operculum and peristome); (c) Reproduction—fusion of sperm and egg, zygote, sporophyte (diploid phase), spore mother-cells, reduction division to spores, protonema, fragmentation, buds and gametophyte (haploid phase).

The Liverwort may be substituted for the moss.

Pteridophytes (Two periods)

The Fern: (a) Habitat, (b) Structure: (i) sporophyte—rhizome, frond (rachis and pinnae), vernation, sori, indusium, sporangium, and annulus; (ii) gametophyte—prothallium, rhizoids, antheridia, archegonia, motile sperms, and egg; (c) Reproduction: sporophyte (diploid), spore mother-cells, reduction division to spores, gametophyte (haploid), fusion of sperm and egg, zygote, embryo sporophyte, sporophyte and fragmentation of rhizome.

Comparison of Bryophytes and Pteridophytes noting such similarities as alternation of generations, independence of gametophyte, necessity of water for fertilization, sexual organs; and such differences as increasing complexity (development of mechanical, vascular, absorptive and food-manufacturing tissues) and independence of sporophyte of the Pteridophytes.

Spermatophytes (Four periods)

A Gymnosperm—Pine: (a) Habitat, (b) General characteristics of pine tree (sporophyte)—leaves, (clustered, thick cuticle and depressed stomata); male or staminate cone (pollen-bearing, axis, microsporophyll, microspo-

rangia or pollen sacs); female or carpellate cone (seed-bearing, axis, scale-like megasporophyll, bract, megasporangia or ovules, and single integument); (c) Life cycle: mature sporophyte (diploid) (i) male cone—microspore mother-cell, reduction division to microspore (wind pollination), male gametophyte, antheridial cell, generative cell, pollen tube, sperms and fertilization; (ii) female cone—megaspore mother-cell, reduction division to megaspore, female gametophyte (endosperm), archegonium, egg, fertilization, zygote, seed (three to eight cotyledons) seedling and mature sporophyte.

Reference to differences between angiosperms and gymnosperms—the gametophyte less developed and specialized, development of ovary wall, double fertilization, development of endosperm, seeds with one to two cotyledons, and flower organ of sexual reproduction.

Reference to advances of Spermatophytes over Pteridophytes (a) pollen tube (obviates need for water) and (b) the seed habit (dissemination, protection of embryo, dormancy, food for embryo and natural improvement of varieties through selection).

Ecology
(Five periods)

Relation of plants to their environment with regard to the following factors:

(a) **Climatic:** light, (leaf structure of sun and shade plants, time of flowering, temperature, wind, humidity and precipitation).

(b) **Soil:** texture—relative size of particles (gravel, sand, silt, and clay); humus; porosity; capillary action; soil solutes—a weak acidic or alkaline solution of oxygen, carbon dioxide and minerals containing nitrogen, calcium, phosphorus, potassium and rarer elements; available water—reference to amount and distribution of precipitation, humidity, water-table level, porosity, and vegetation; air—soil aeration and drainage are closely related; organic decay; temperature—determining factors: sun, drainage, location, and humus content.

(c) **Biotic:** competition among different species of plants, grazing, parasitic diseases (reference to examples), harmful and beneficial insects (examples only), soil bacteria (reference to nitrogen-fixing and denitrifying bacteria), earthworms (aerating, grinding and enriching the top layer of earth).

Heredity
(Six periods)

A discussion of relative effects of environment, (nutrition, light, water), and heredity on the growth of animals and plants.

Consideration of conditions for the study of heredity:
(a) Environment does not explain why (i) offspring resemble parents, (ii) offspring are not exactly like their parents.

(b) Mendel's experiments with pea plants of contrasting characters to show (i) that the first generation following a cross is like one parent, (ii) that the members of the second generation crossed among themselves give

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offspring showing 3:1 ratio.

(c) Explanation of above in terms of (i) dominant and recessive characters, (ii) segregation.

(d) Blending or incomplete dominance—snapdragon, four-o'clock.

(e) A consideration of the chromosome theory of inheritance and the gene; reference to cell division (Mitosis) and chromosome reduction (Meiosis), noting the gene constitutions of the parents and gametes in both pure breeds and hybrids.

REFERENCE BOOKS

Elements of Botany. Holman and Robbins, Renouf Publishing Co.
Biology. Moon and Mann, Clarke, Irwin & Co.
Basic Course in Botany. Pool, Ginn & Co.
Biology—The Science of Life. MacDougall and Hegner, McGraw Hill.

Elementary Reference Books (Not Suitable as Texts)

Dynamic Biology Today. Baker and Mills, W. J. Gage & Co.
New Introduction to Biology. Kinsey, Longmans, Green & Co.
Biology for You. Vance and Miller, Longmans, Green & Co.

SUGGESTED EXPERIMENTS

in

GRADE XIII BOTANY

The following information is intended to serve as a guide for the practical work in Botany. The experiments are so selected that classes provided with very ordinary equipment can follow them with advantage. It is hoped that teachers may find it possible at the appropriate seasons to make collections of material for the practical work in the laboratory.

Respiration in germinating seeds: Set up two flasks each with a two-holed stopper, two pieces of glass tubing, two pieces of rubber tubing, and two pinch clamps. Place seeds covered with water in one and an equal volume of water in the other. Set aside, sealed off for a few hours. Displace the air from the two flasks through limewater and compare the effect of each on limewater.

Spirogyra: Floating masses of Spirogyra usually occur in slowly moving streams, ponds, and ditches. In midwinter they may be collected from springs which do not freeze over. They occur most abundantly in the spring and usually may be identified by the fact that in the vegetative stage they feel silky to the touch.

Osmosis: The following substances function well as semi- or differentially-permeable membranes; parchment paper, ox or pig bladder, non-waterproof cellophane, and sausage casing. By using lukewarm water positive results may be obtained by the end of the lesson period.

See Bowers, General Science, Book I, page 177.

Plasmolysis: Mount living Spirogyra, Elodea or any green plant-cells in water, cover with a cover glass and examine under a microscope. Examine the distribution of the chloroplasts. Place two or three drops of salt or sugar solution along the edge. From the opposite side withdraw the water with a blotter. Note the effect on the distribution of the chloroplasts. Optional—Remove the cells and place in water for several minutes. Examine as above.

Production of root-hairs: Drop seeds of radish, red-top grass, corn, etc., into an antiseptic solution for 1-2 minutes. Rinse and place on moistened blotting-paper or on a thin agar solution in a covered Petri dish for a few days. Mount the roots of the grass seedlings in water and examine them under a microscope for the epidermal cells with the root-hairs.

To show the region of elongation in roots: Select germinating bean seeds with hypocotyl about one inch long and mark uniformly with India ink using a horsehair or a wheat beard to produce the fine lines. Replace on moistened blotting paper and examine in 1 or 2 days.

To show the region of elongation in stems: Select rooted pea or bean seedlings with at least 2 - 3 nodes above the hypocotyl and mark uniformly with India ink (horsehair or wheat beard) for 2 or 3 nodes back of the top. Examine in 2 or 3 days.

Micro-examination of leaf epidermis: Wrap a wilted leaf of geranium or wandering jew about the forefinger. With a sharp knife strip off an epidermal piece free of chlorenchyma. Mount in water. Compare upper and lower surfaces.

Location of stomata: Drop a thick leaf (Bryophyllum, rubber plant, sedum) into **hot water.** Note the bubbles rising, rather regularly distributed over the surface.

Starch test in green leaves: Do leaves contain starch? Is starch present in leaves which have been kept in darkness? See Bowers, General Science, Book I, page 235; Bruce, Junior Science, Part I, page 152.

Release of oxygen in photosynthesis: See Suggested Experiments in Science, Grade IX; Bowers, General Science, Book I, page 241; Bruce, Junior Science, Part I, page 153.

Need for carbon dioxide for a plant: Place boiled water and waterweeds in two jars and provide the one with a carbon dioxide bubbler (1 - 2 minutes at 5 - 6 hour intervals) or see Bowers, General Science, Book I, page 239.

Transpiration: See Bowers, General Science, Book I, page 229; Bruce, Junior Science, Part I, page 155.

Culture of bacteria: See Bowers, General Science, Book II, page 115.

Culture of fern prothallia: Collect and dry fern leaves with mature spores. Thoroughly clean a flower-pot and fill with moss or paper towelling. Invert in the saucer, set on a glass plate and invert a battery jar over it. Shake fern-spores on the flower-pot and keep moistened. The prothallia should mature in 8 - 10 weeks if kept in a cool north window.

To secure sperm, allow a few prothallia to wilt but not dry out. Place them on a drop of water on a slide and the sperm will likely be observed swimming about within 2 or 3 minutes.

ZOOLOGY

The practical study of the external form of all types, and the dissection or study of prepared specimens (or models), as specified below. Observational drawings are essential.

In the case of each of the following animals the characteristics of the group to which it belongs should be studied.

Arthropoda
(Seven periods)

Insecta

(a) The grasshopper. The practical study of the living animal noting habitat and habits (feeding, breathing, jumping, flying, crawling, and egg laying). The external features (body parts, segmentation, sense organs, mouth parts, wings, legs, and ovipositor); mode of breathing (spiracles, tracheae, air sacs, air movements, and gas exchange); the life history; and the characteristics of the order Orthoptera.

(Six periods)

(b) May beetle, monarch butterfly, mosquito, dragon fly, squashbug, and ichneumon fly. A **brief** description of the external features of the adult of the above mentioned insects with special attention paid to the wings and mouthparts which serve as a basis of classification into their respective orders of Coleoptera, Lepidoptera, Diptera, Odonata, Hemiptera, and Hymenoptera.

The life history: egg (where and when laid); larva or nymph (habitat, food and feeding habits, breathing, and the approximate time spent in this stage); and the pupa (where found).

Arachnida

(Two periods)

The practical study of the main external features of a spider as a basis for comparison with an insect noting the body divisions, absence of antennae, four pairs of legs, eyes, spinnerets, and breathing organs. A brief reference should be made to the web and its uses.

Crustacea

(Five periods)

The practical study of a living crayfish noting the habitat and habits (breathing, swimming, walking, and feeding). The external features (body parts, segmentation, covering, sense organs, legs, swimmerets and such modified appendages as "pincers" and uropods).

Breathing: nature and location of gills, water movements, and gas exchange. Life History: eggs, care of young, and frequent moulting.

Annelida
(Seven periods)

The earthworm. The practical study of the living animal—habitat; habits; external features (shape, covering, segmentation, clitellum, openings, and setae); and locomotion. Dissection to show the internal structure (digestive organs, dorsal vessel, heart, reproductive organs, septa, and nerve cord). A study with the low-power of the microscope of a cross-section posterior to the gizzard noting the cuticle, ectoderm, setae, muscles, blood vessels, intestine, typhlosole, nerve cord, and nephridia. The names and functions of the chief digestive

organs. Respiration (thin moist skin, richly supplied with capillaries).

Protozoa (Three periods)

The amoeba. A practical study of the living animal under the microscope. The discussion of habitat; movements; structure of cell (nucleus, contractile vacuole, food vacuoles, ectoplasm, endoplasm, and pseudopodia); and functions (food getting, digestion, egestion, assimilation, excretion, respiration, growth, and reproduction).

A similar study of the paramoecium may be substituted for that of the amoeba.

Human Physiology (twenty-five periods)

Vertebrata Introductory (Two periods)

Organization of the body into cells, tissues, organs, systems.

Metabolism — meaning, processes, measurement of metabolic rate.

Nutrition (Six periods)

Meaning; need for food, types of food.

Digestion—significance of digestion, general plan of digestive tract; mechanical processes, i.e., action of teeth, swallowing, movements of stomach and intestines; chemical processes, i.e., glands and secretions, kinds and role of enzymes, digestion in mouth, stomach, duodenum, small intestine, functions of liver and pancreas.

Absorption—in small and large intestine, villi, absorption of fats, proteins, carbohydrates.

Transportation of food—by blood, lymph, lacteals.

Storage of food—body fats, glycogen.

Assimilation—building of protoplasm.

Respiration (Four periods)

Oxidation with release of energy; respiration vs. breathing. Breathing organs; nature of lungs, alveoli, moist surface, diffusion of oxygen and carbon dioxide, role of haemoglobin. Mechanics of breathing; composition of inhaled and exhaled air; regulation of breathing determined by carbon dioxide in blood.

Ultimate zone of respiration is the living cell.

Circulation (Four periods)

Use of transportation system; composition of blood; changes in colour of blood — haemoglobin, oxyhaemoglobin.

Heart and its action; nature of arteries, capillaries, veins; blood pressure, nature of pulse.

Nature and purpose of: pulmonary circulation, systemic circulation, hepatic portal, coronary circulation of heart, lymph. (Note.—Only the general plan of each part of the system and the names of a few of the chief arteries and veins are expected.)

Special blood functions: blood clotting, resistance to disease, regulation of heat.

Execretion (Two periods)

Meaning of excretion, nature of waste products.

Chief organs of excretion, kidneys, lungs, skin; twofold action of kidneys — filtering and reabsorption; ureters, bladder.

Co-ordination and Control (Seven periods)

Chemical regulation by endocrine glands—thyroid, adrenal, pancreas, pituitary.

Nervous regulation—nervous systems, central, autonomic, peripheral (nerves), functions of cerebrum, cere-

bellum, medulla and spinal cord.
Neuron, reflex arc.
Sense organs—eye, ear.

(Seven periods)

Pisces. The practical study of a living fish (a perch or goldfish) to show the movements associated with breathing, locomotion, balancing, and feeding. The external features with special attention to adaptations to environment and habits. These should include shape, colour, covering, organs of locomotion, and external sense organs.

Breathing organs: situation; number; parts; functions of parts; and such significant characteristics of the filaments as their thin covering, large surface, abundant capillaries, and means of protection.

Circulation: single circuit from heart to gills to body to heart. The course of the blood is to be traced through the heart to the gills and to the dorsal blood vessel noting the nature of the blood (rich in nutriment, deficient in oxygen) passing through the heart.

Life History: favourable breeding grounds; eggs (very numerous, fertilized after laying, large yolk supply); and high mortality. (The cleavage stages are to be omitted.)

(Thirteen periods)

Amphibia. The practical study of a living frog to show movements associated with breathing (throat, nostrils, and sides); feeding (head, mouth, and tongue); and locomotion (swimming, jumping, crawling, diving, and burrowing).

Note—the toad may be used for some of the above observations.

The microscopic (low-power) observation of the flow of blood (plasma and corpuscles) in the web of the foot (or in the tail of the tadpole).

External features—shape, moist skin, large mouth, nostrils, eyes, ears, and limbs.

The name, location, and function of the chief organs of:

Respiration—nostril, mouth, trachea, lungs, and skin.
Digestion—mouth, gullet, stomach, intestine, liver, and pancreas.
Excretion—kidney, ureter, lungs, and skin.
Reproduction — testes, ureter, ovaries, oviducts, and cloaca.
Circulation—incomplete double circulation, three chambered heart, truncus arteriosus, and its three main branches. (The venous system is not required.)

Note—If the human physiology section has been covered previously needless repetition should be avoided.

Nervous system—Dorsal view of brain (olfactory lobes, cerebrum, optic lobes, cerebellum, medulla); spinal cord; and spinal nerves (number, relationship to vertebrae, and fusions to form brachials and sciatics).

Skeleton:

Skull—omitting structural details but noting relatively

small cranium and the protective "ear" and "nose" capsules.

Vertebral Column—number of vertebrae, and the structure of a typical vertebra. Note the specialized nature of the terminal vertebrae and the urostyle.

The girdles (a) Pectoral, bones of each half—coracoid, clavicle, scapula, and supra scapula) and the sternum; fusion. (b) Pelvic, each half (ilium-ischium-pubis fusion) noting attachment of the ilium to the sacral vertebra.

The limbs—names of chief bones, noting fusions.

Life History—spawning, fertilization, egg, zygote, cleavage (2, 4, 8 and many cells), layers (outer, inner and middle), the fact that the organs and tissues develop from these layers. The tadpole, transformation to the adult noting the changes in the feeding, breathing and locomotion habits which accompany structural changes.

Dissection to show organs of respiration, circulation, digestion, excretion, and reproduction.

(Two periods) **Reptilia.** The practical study of a snake noting the external features (shape, colour, covering, eyes, nostrils, and tongue) and the adaptations of the mouth and jaws to its feeding habits.

Locomotion.

(Seven periods) **Aves.** The practical study of a bird:

External features—shape (spindle), beak, nostrils, eyes and eyelids, covering, ears, neck, wings, tail, and feet (scales and claws).

Plumage—names and functions of feathers. Description of a quill feather.

Skeleton:

Skull,—thin bones, absence of teeth, prolongation of facial bones to form beak, large eye orbits, and a single occipital condyle.

Vertebral Column—flexibility of cervical vertebrae, rigidity of trunk vertebrae, and fusing of vertebrae to form pygostyle.

Ribs and breastbone,—wide sternum with keel.

Shoulder girdle—fused clavicles, large coracoids, and long narrow scapulae.

Bones of fore limb,—note fusing of carpus with metacarpus.

Pelvic girdle,—fusing of bones to each other and to backbone.

Bones of hind limb,—note fusing of tarsals with tibia and metatarsus.

Adaptations to flight with special reference to (a) shape (b) covering (streamlining, decreased density, tail quills, and wing quills), (c) skeleton (light bones which are thin or hollow, strengthening of shoulder region, fingers reduced, fusing and lengthening of "hand" and wrist bones, "hand" bent back, ribs braced, sternum and keel enlarged for attachment of muscle, rigidity and flexibility of various regions of vertebral column), (d) breathing (lungs, air sacs, reciprocal flow of air, and

synchronization of breathing and flying movements).

Organs of digestion and their functions.

(Four periods)

Mammalia. A brief survey of mammals to show the basis of classification. The main characteristics, with examples, of the following orders:

R o d e n t i a — typically vegetarian, incisors (chisel shaped, self sharpening and continuously growing), canines absent, and molars (broad and grooved).

Carnivora—small incisors, large interlocking canines, shear-cutting molars, and feet usually provided with claws.

Ungulata—grinding molars, and feet with hoofs.

Primates—erect or nearly so, superior brain development, eye orbits directed forward, forelimbs fitted for grasping, and usually flat nails instead of claws.

A study of mammalian skeleton—nature (bone and cartilage), function (support, protection and attachment of muscle).

Skull—many bones, large cranium, large eye orbits, occipital condyles, and foramen magnum.

Vertebral Column—description of a typical vertebra, specialization of atlas and axis, five main regions of vertebral column pointing out the variation in size and form of vertebrae.

Pectoral girdle—description of scapulae and clavicles.

Bones of fore limbs (little or no fusion).

Pelvic girdle—names and situation of bones.

Bones of hind limb—note the similarity of plan of the hind limb and the fore limb.

(Two periods)

A review of the distinguishing characteristics of the groups to which the animals studied belong. These groups are Protozoa; Annelida; Arthropoda (Crustacea, Insecta, and Arachnida); and Vertebrata (Pisces, Amphibia, Reptilia, Aves, and Mammalia).

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Colleze Zoology. Hegner, Macmillan Co. of Canada.

Biology. Moon and Mann, Clarke Irwin.

Human Body and Its Functions (Special Edition). Best and Taylor, W. J. Gage & Co.

Biology—The Science of Life. MacDougall and Hegner, McGraw Hill.

Elementary Reference Books—(Not suitable as texts)

Dynamic Biology. Baker and Mills, W. J. Gage & Co.

New Introduction to Biology. Kinsey, Longmans, Green & Co.

Biology For You. Vance and Miller, Longmans, Green & Co.